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Systematic Review

The Evolution of Digital Building Logbook: Exploring Building Information Gathering Systems to Boost Building Maintenance and Renovation

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Abstract: The architecture, engineering, construction, and operations industry is distinguished by having plenty of and a variety of data, which makes the acquisition, storage, retrieval, and use of information difficult. Due to a data exchange system primarily based on paper-based transmission, multiple classification systems, the use of inconsistent criteria and practices, and a significant number of stakeholders involved during the building life cycle (each with distinct requirements and levels of access to information), the entire construction process must deal with ineffective information exchange among actors. Instead of multiple sources of information and tools to collect, store, and share data, one single source of information could become a reference point for numerous stakeholders. In this regard, a digital building logbook is assumed to be a collector of building-related data starting from the design phase, which plays a fundamental role in information management. This paper proposes a systematic literature review aimed at identifying the main features of the tool, investigating its growth in the construction sector. The results show that the digital building logbook's main application is in the operations and maintenance field with relevance to renovation. However, a common model is absent, varying greatly based on the country and category of building. This analysis contributes to increasing awareness by identifying the attributes, gaps, and potentialities of the subject matter.

Keywords: digital building logbook; digitalization; building passport

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1. Introduction

The architecture, engineering, construction, and operations (AECO) sector produces significant amounts and diverse types of data during the building life cycle, leading to the fragmentation of the sector and the need for extensive information management [1]. This diversity complicates the processes of collecting, storing, sharing, and updating information. Moreover, stakeholders involved in different lifecycle stages acquire data in inconsistent ways, leading to decisions that are often based on the availability of such data rather than their completeness or accuracy. Furthermore, data storage is fragmented and scattered across multiple organizations, and even among different departments within the same organization. Data collected and stored by one individual entity may not be readily accessible or available to other stakeholders in the value chain [2]. These issues linger and intensify during the in-use phase of the building lifecycle when interventions (e.g., renovation) occur. In fact, in this specific stage, data and information exchange as

well as stakeholders are more numerous and various, and consequently, the collection, management, and use of information can be complex [3,4]. As a result, this can lead to data being compromised and incompatible with systems used by other stakeholders, creating information asymmetry, reducing transparency, and complicating decision making [5,6]. However, there are no established guidelines regulating how data should be collected, organized, and accessed by the involved parties [7].

Given the poor information exchange in building stocks and the lack of coherent, high-quality information [8,9], a homogeneous collection and management system is required. According to the European Commission (EC), a systematic, organized, and standardized framework for data collection and storage would mitigate these issues. Although methods such as the Data Capability Assessment Model (DCAM) help organizations identify gaps in their data practices, align data management with business objectives, and implement best practices for data governance and quality, the lack of a systematic method for capturing, storing, analyzing, and organizing building-related data leads to the loss of valuable information [10].

In this regard, a digital building logbook (DBL) is an essential tool for modern building management, offering a streamlined, efficient way to manage and access building data, ensuring better performance, compliance, and sustainability.

The concept of a digital building logbook, defined as "a common repository for all relevant building data, including data related to energy performance such as energy performance certificates, renovation passports, and smart readiness indicators, which facilitates informed decision making and information sharing within the construction sector, among building owners and occupants, financial institutions and public authorities" [8], has been introduced only in recent years and remains an optional tool within the European AECO sector. The European Commission presented the idea of a digital building logbook in the Renovation Wave report in 2020 [11], and it clarified the need for this element in the Energy Performance of Building Directive (EPBD) the following year [8]. The European Commission stated that the national databases for the energy performance of buildings should be interoperable and integrated with other databases with building-related information (e.g., national building cadasters and digital building logbooks) in response to the inadequate information exchange in the European building stock, as well as the lack of coherent, high-quality information [8]. However, before its introduction by the European Commission, the concept of a tool aiming at collecting building-related information, better known as a "Building Passport (BP)" or "Building Logbook", was developed and used across Europe in different ways. Therefore, several national versions of the building logbook with different involved stakeholders, requirements, and features exist according to the country considered [2].

A digital building logbook, by gathering and organizing data related to a building [5], can serve multiple purposes, such as enhancing building efficiency [12], supporting maintenance strategies, managing technical aspects, ensuring safety, and preserving economic value [13]. It also helps reduce the time and cost associated with retrieving missing information [5] and promotes digitalization within the AECO sector [2]. Additionally, a digital building logbook plays a crucial role in facilitating building renovation [2]. According to Volt et al. [2], the digital building logbook can support initiatives like the "Renovation Wave" [11], which aligns with the "European Green Deal" policy set by the European Commission [14]. It encourages renovation by compiling data on building performance and maintenance throughout its lifecycle, aiding in the development of renovation roadmaps, maintenance planning, and decarbonization progress assessment [2]. These data should be integrated with the official document that rates the energy efficiency of buildings (Energy Performance Certificate—EPC), technical inspection reports, the Smart Readiness Indicator

(SRI), which assesses a building's ability to use smart technologies, or building renovation passports to provide a comprehensive understanding of the building and its energy efficiency, as well as to minimize performance gaps. Consequently, having all this information leads to better-informed decisions about when and how to undertake renovations [2]. Moreover, the digital building logbook, functioning as a repository for building-related information, can be incorporated into the building renovation passport [15] and linked with a renovation roadmap [15,16], which outlines each step of the renovation process [15].

Information related to building type and age, property plans and obligations, periodic synthesis data resulting from sensors continuously monitoring the indoor climate (air temperature and air relative humidity), indoor air quality (CO_2 concentration and volatile organic compound (VOC) content), and thermal comfort (predicted percentage of dissatisfied (PPD) and predicted mean vote (PMV)), information on energy consumption and energy costs, and the main significant interventions executed for maintenance (e.g., boiler replacement) can be collected within the digital building logbook [17–20].

Given this scenario, this research aims to report on the status of the digital building logbook tool through a systematic review based on published research articles. The study will comprise an analysis of the main information that can be collected within the digital building logbook, taking into consideration the different purposes that the tool can serve during the different phases of the lifecycle. Along with this, the paper investigates the role that the digital building logbook can have in supporting the circular economy. Finally, even considering an instrument that collects building-related data like the digital building logbook, there is a need to question data management and related issues.

This research aimed to answer the following key question: What is the status of the building logbook and the state of the art of the AECO field? The exchange of data and information has become more frequent, and the number and variety of stakeholders involved have increased during the in-use phase; as a result, managing, collecting, and using this information have become more complex. Therefore, the study focuses on understanding to what extent the digital building logbook impacts operations and maintenance, supporting more efficient facility management (FM).

For this purpose, a specific search including both "digital building logbook" and "AECO" concepts has been performed in two databases (Scopus and Web of Science). In total, 25 results have been collected, categorized, and analyzed from 2010 to 2024. The year 2010 was deemed a reasonable starting point for the investigation, as discussions about building logbooks were minimal before that time and particularly were more connected to a paper-based format still. The results included journal articles, conference articles, book chapters, and reviews.

To address the research question, the article is organized as follows: Section 2 describes and justifies the research method and classification criteria used to identify, include, and exclude articles from the review; Section 3 presents both a bibliometric and thematic analysis of the selected sources; and finally, Section 4 discusses the final results.

2. Materials and Methods

In this study, a systematic literature review (SLR) approach, which provides a more thorough and structured overview of the literature compared to a descriptive review, has been adopted. SRL is an effective approach for identifying new research opportunities within a specific field by analyzing and synthesizing existing published works. The SRL developed focused on the digital building logbook concept in order to find information about this tool in the construction sector. The search focused on results, articles, and publications that contain key terms relevant to the research objective in their titles, abstracts,

and author keywords. To simplify and make clear the process of the literature review, a research protocol was defined (Table 1).

Table 1. Research protocol.

Item	Content
Aim	
Key objective	To examine the current studies on building logbook implementation in the AECO sector with special attention given to the in-use phase of the building lifecycle
Research questions	
Main question	What is the status of the building logbook and the state of the art of the AECO field?
Sub question	What types of data are typically stored in a digital building logbook? How does the digital building logbook support the building's entire lifecycle? To what extent does the digital building logbook impact facility management?
Search methods	
Web-based platform	Scopus, Web of Science
Filters	
Keywords	((“Building Logbook” OR “Logbook” OR “Passport” OR “Building Passport” OR “Digital Building Logbook”) AND (“AECO” OR “AEC” OR “Construction” OR “Building”) AND (“Facilit*” OR “FM” OR “Facilit* management”))
Year of publication	2010–2024
Type of publication	Articles, books, book chapters, conference papers
Idiom	English
Exclusion criteria	
	Not related to the digital building logbook
	Outside the time period
	Abstract not available for download
	Not written using the defined terms
Method of review	
Data extraction	Excel spreadsheets to check papers, authors, and features based on the protocol
Narrative synthesis	Bibliometric Analysis: • publications over time; • publications' distribution in journals. Qualitative Analysis: • analysis of selected publications: building logbook concept, implementation, existing building logbooks; • description of findings, outcomes, and relationships.

Scopus and Web of Science databases were utilized to conduct the study in order to guarantee that a sufficient amount of research regarding the use of logbooks in the construction sector was collected and evaluated. These two databases were chosen since they are both global and multidisciplinary platforms for accessing research literature. The timeframe established spanned from 2010 to 2024 to identify the publications related to building logbook implementation from the initial insights regarding the AECO field's use of this tool. A comprehensive search was carried out under the “Article title/Abstract/Keyword” field with the search string consisting of three parts. The first part investigated the tool of interest and comprised keywords related to “Building Logbook”, “Logbook”, “Passport”, “Building Passport”, or “Digital Building Logbook”. The second part aimed to specify the context of analysis and involved keywords such as “AECO”, “AEC”, “Construction”, or “Building”. Lastly, the third part considered the domain of facility management and relevant keywords related to “Facilit*”, “FM”, or “Facilit* management”.

The literature analysis was carried out according to the outlined methodology and led to the results shown in the PRISMA diagram in Figure 1 [21].

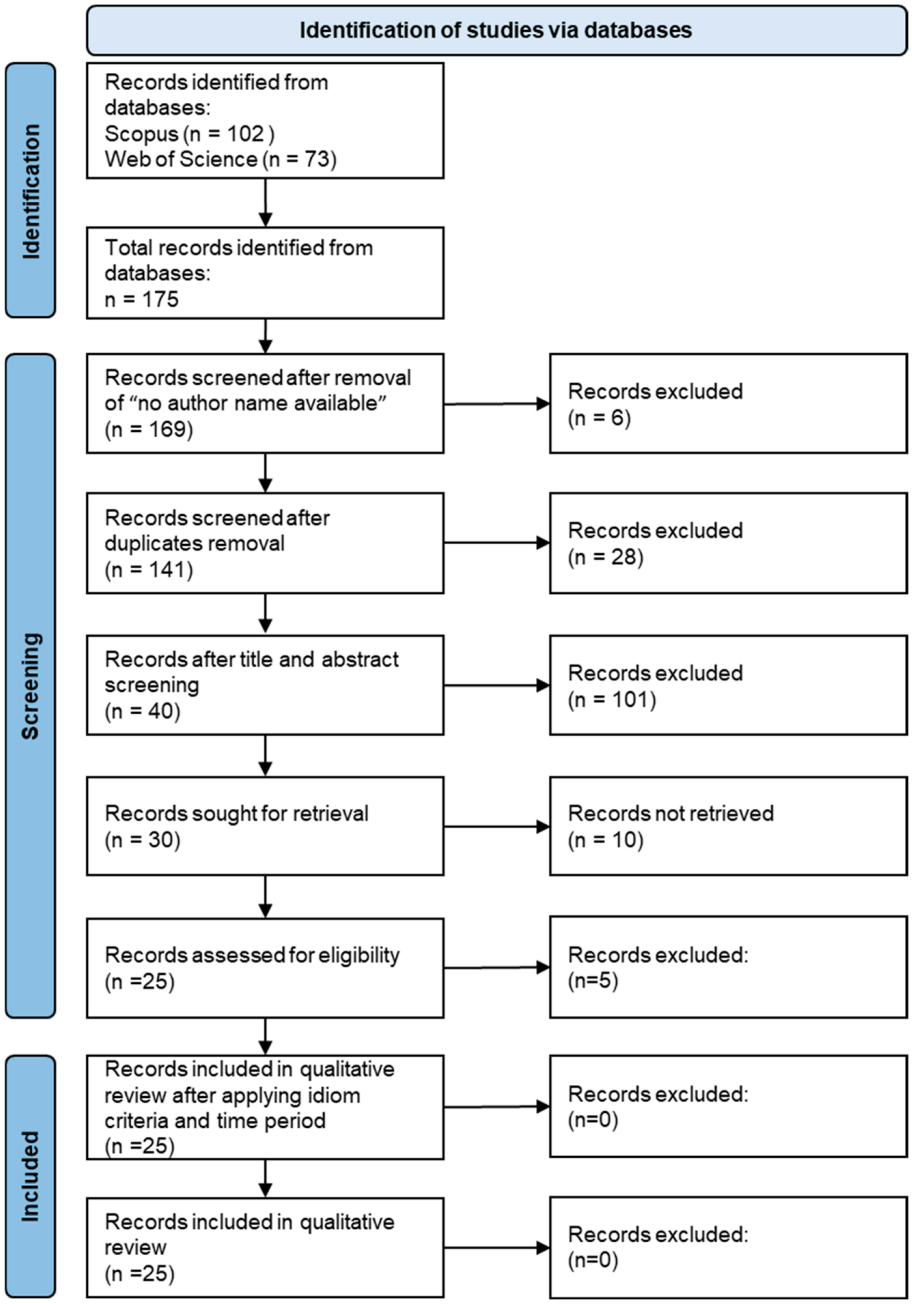

Figure 1. PRISMA diagram (authors' elaboration based on PRISMA framework guidelines [21]).

A total of 175 publications were retrieved from the search query. After removing papers without author names and duplicates, 141 publications were retrieved. Afterward, a screening by reviewing titles and abstracts was performed to identify papers relevant to the research question and then to remove publications whose subject of interest was not related to the construction sector or simply included some of the keywords in their "title, abstract, or keyword" sections. The total number of papers after this stage was reduced to 40. Removing the articles for which the full text was not found, the number of articles in preparation for full-text screening was obtained. The full text for these articles was reviewed to assess their eligibility for inclusion in the systematic review. Twenty-five publications were considered eligible for additional analysis following the screening phase. Finally, after examining the publications and applying term criteria and time period limitations, the number of publications included in the qualitative review was 25.

3. Results

3.1. Bibliometric Analysis

A bibliometric analysis was employed as an evaluation tool within qualitative research methods because it can evaluate the influence of the reviewed publications, and the results can aid in decision-making processes [22,23].

The initial analysis concentrated on the timeline of the publications' distribution shows a growing trend, with a peak in 2023–2024. Therefore, the concept of the digital building logbook in the construction industry is quite new and has spread in recent years (Figure 2).

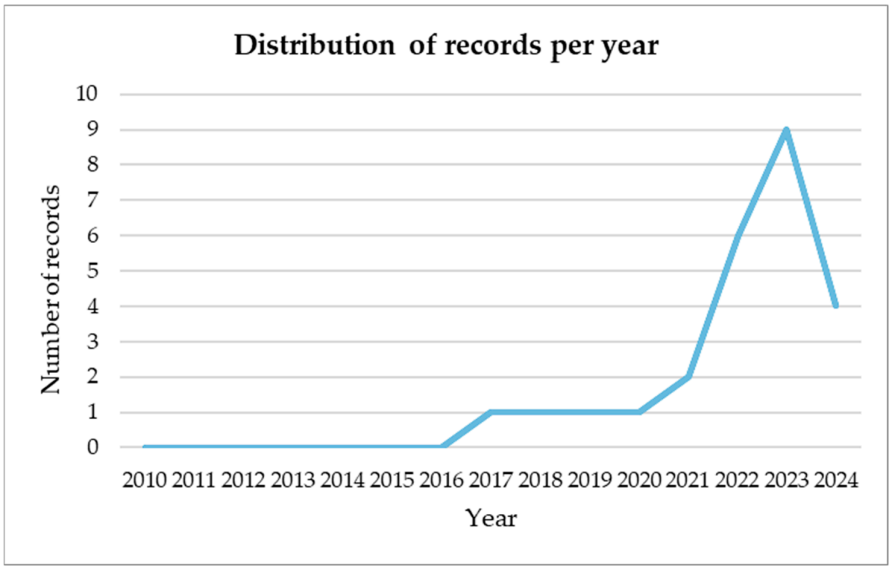

Figure 2. Distribution of digital building logbook records from 2010 to 2024.

In addition, an analysis of the different natures of the records on a yearly basis was conducted. The publications were subdivided into three main groups according to the different types of scientific documents: articles, conference papers, and other. The most popular publication type is conference papers, which predominate in 2022, 2023, and 2024 with a total of 12 records, followed by articles with a total of eight records, and finally, book chapters and reviews, grouped under the "Other" group, with five records. Figure 3 presents the document type distribution per year.

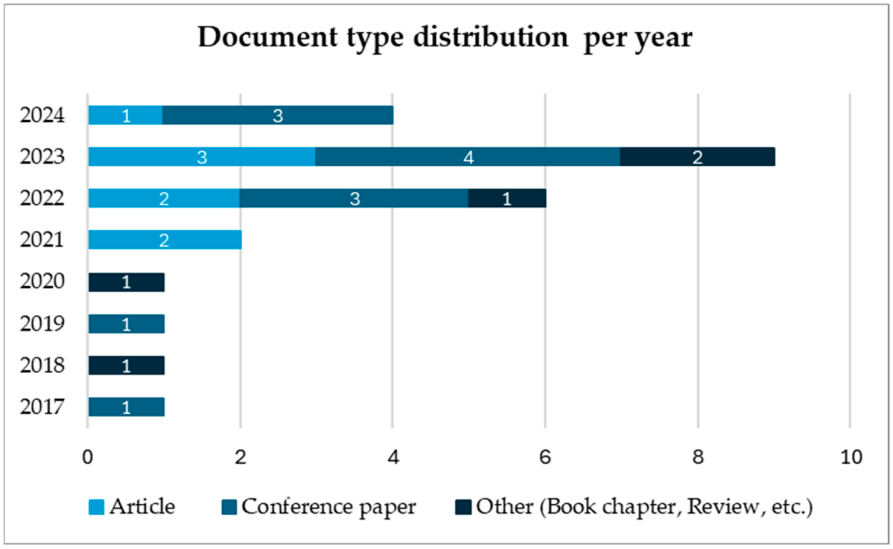

Figure 3. Distribution of digital building logbook document type from 2010 to 2024.

Concerning scientific publications in peer-reviewed journals and conferences, the findings are reported in Table 2. A detailed breakdown of the articles across specific journals by year is provided. The data show a quite homogeneous distribution of records among the different sources, with Sustainability having the highest number of records.

Table 2. Records by journal and year of publication.

Source Title	Reference	Total	2017	2018	2019	2020	2021	2022	2023	2024
Journal of Physics: Conference Series	[24]	1							1	
Proceedings of the European Conference on Computing in Construction	[25]	1								1
ISC2 2022—8th IEEE International Smart Cities Conference	[26]	1						1		
IFIP Advances in Information and Communication Technology	[27]	1							1	
Resources, Conservation and Recycling Advances	[28]	1						1		
IET Conference Proceedings	[29]	1							1	
Procedia Engineering	[30]	1	1							
2022 7th International Conference on Smart and Sustainable Technologies, SpliTech 2022	[31]	1						1		
IOP Conference Series: Earth and Environmental Science	[32]	1			1					
14th International Conference on Information, Intelligence, Systems and Applications, IISA 2023	[33]	1							1	
AHURI Final Report	[34]	1							1	
Journal of Building Engineering	[35,36]	2					1		1	
Eceee Summer Study Proceedings	[37]	1						1		
Sustainability (Switzerland)	[38–41]	4				1	1		1	1
Urban Book Series	[42,43]	2							2	
Lecture Notes in Civil Engineering	[44]	1								1
Procedia Computer Science	[45]	1								1
Energies	[46]	1						1		
Energy and Buildings	[16]	1		1						
Buildings	[47]	1						1		

The final component examined in the bibliometric analysis was the research methods employed to investigate the topic of the digital building logbook in the construction sector. The analysis revealed that three key research strategies dominate the sample: case studies, literature reviews, mixed methods approaches, and other typologies. In terms of research methodology, literature reviews, case studies, and mixed methods use distinct approaches, each serving different purposes in the investigation of a topic. A literature review aims to synthesize and analyze existing research on a specific topic, identifying trends, gaps, and key findings. A case study aims to explore a specific instance, event, or entity (such as an organization, community, or project) in-depth over time. Mixed methods combine both qualitative and quantitative research methods to provide a more comprehensive

understanding of a research problem. Finally, questionnaire/surveys and experimental studies were grouped as "Other". Questionnaires, as a research technique, allow for the collection of qualitative and quantitative data from participants for further analysis. An experimental or empirical study uses a scientific approach, in which experiments are conducted to test competing models or hypotheses. The findings indicate that a significant portion of the articles (10/25) utilize case studies for their research development, while an equal number of authors (7/26) opt for other research methods, such as a questionnaire or experimental study (Figure 4).

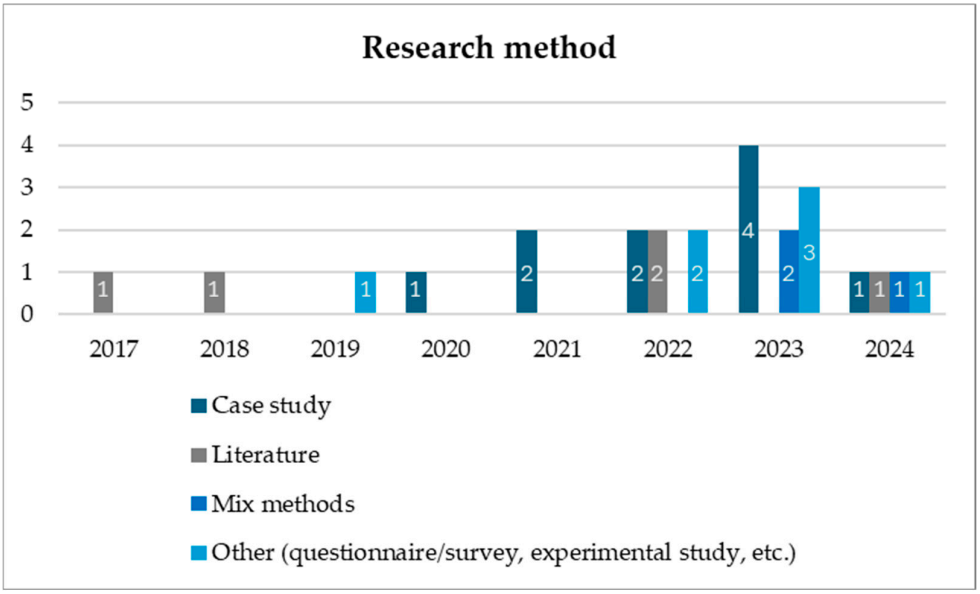

Figure 4. Research methodology adopted in selected records.

3.2. Thematic Analysis of Selected Articles

This section discusses the research findings, analyzing the digital building logbook regarding different topics. Given the nature of the digital building logbook, which centralizes information related to a building, this section involves examining its structure and the data categories into which it is divided (Section 3.2.1). Furthermore, since it plays a crucial role throughout the building lifecycle, enhancing mainly efficiency and decision making, its main applications during several building lifecycle stages were investigated (Section 3.2.2). Its contribution to the circular economy by supporting sustainability was also taken into consideration (Section 3.2.3). Finally, the digital building logbook is revolutionizing building data management by offering a structured, centralized, and accessible platform. For this reason, its data management function was analyzed (Section 3.2.4).

3.2.1. Digital Building Logbook Structure and Data Categories

The first analysis carried out focused on the description of the digital building logbook initiative. Only some of the reviewed articles include the presentation of a digital building logbook initiative. Despite numerous national initiatives focused on defining the concept and features of the digital building logbook, it is inferred that the so-called logbook still misses a uniform and standardized framework [2,46]. A common set of indicators is absent and those vary greatly depending on the country and the category of building. However, since the implementation of the digital building logbook is a priority for Europe in order to boost renovation, efforts to create a common digital building logbook come mainly from H2020 projects such as iBroad, ALDREN, and X-tendo. Moreover, among the analyzed papers, there is a reference to national initiatives such as the German logbook Bauwerksbuch and the Spanish logbook Libro de Edificio [27,39].

A list of digital building logbook initiatives as represented in the analyzed papers is represented in Table 3.

Table 3. Digital Building Logbook initiatives.

Horizon Europe Initiatives	Reference
ALDREN	[36,40,47]
iBRoad	[36,37,46]
X-tendo	[36]
BIM4EEB	[27]
DigiBUILD	[33]

ALDREN (A Long-term Renovation and Energy efficiency Network) is a Horizon2020 project which has developed a digital building logbook known as the ALDREN BuildLog [48]. This tool serves as a comprehensive digital repository for crucial building data, including ownership details, design specifications, materials used, operational costs, and energy performance indicators [36]. The goal is to create a structured and easily accessible overview of a building throughout its life cycle, facilitating better decision making for renovations and energy efficiency improvements. It is designed to complement existing energy performance certificates and provides a clear picture of a building's current condition and its renovation potential [46]. The ALDREN BuildLog is modular and consists of six distinct modules that allow for tailored data collection according to the specific needs of building owners and managers. This flexibility is essential for creating a long-term renovation roadmap (referred to as the RenoMap), which outlines strategies for achieving energy efficiency targets [40].

The iBRoad project (Individual Building Renovation Roadmaps) developed the Individual Building Renovation Roadmap. It was a customized and long-term (5–30 years) step-by-step plan for building renovation [49]. A key feature of the iBRoad initiative is its digital building logbook, which serves as a centralized repository for all relevant information about a building [37]. Supported by a logbook with building-related information after an on-site building assessment and an interview with the homeowner, a trained energy auditor implements the roadmap [36,46]. The auditor uses the iBRoad software (iBRoad-Plan) to present a step-by-step improvement plan, taking into account the homeowner's needs and preferences.

Another Horizon2020 project that developed a logbook is X-tendo [50]. It aims to enhance building energy performance and improve Energy Performance Certificate (EPC) schemes using innovative tools. X-tendo developed a toolbox to help public authorities or implementing agencies strengthen existing EPC frameworks. This toolbox includes innovative EPC indicators, such as smart readiness and comfort, and innovative data handling, such as EPC databases, enhanced recommendations, financing options, one-stop shops, and building logbooks [36]. A logbook serves as a centralized repository for building data, aiding energy efficiency efforts and renovations.

The BIM4EEB Horizon2020 project developed a building logbook containing information related to the building as well, and it focuses mainly on the renovation the building is undergoing [51]. The tool is available on the digital platform BIM Management System (BIMMS) developed within the project, in which a specific section is reserved. The logbook was created in a digital format, and it may be accessed immediately from the BIMMS where it is maintained. The logbook is organized into groups of information with different fields that need to be compiled and viewed by different users, like the inhabitants of, owners of, and professionals involved in the building. A data field in the logbook can be written by

different users, taking into account their role in the project. According to various levels of permission, it is available to all parties involved in the building renovation process [27].

The DigiBUILD Logbook is part of the broader DigiBUILD initiative, a project funded by Horizon Europe, which focuses on using digital technologies to support energy-efficient building renovations and management [52]. The goal is to deliver a digital logbook that offers analytical services for the building sector [33]. It is an online platform that allows various building stakeholders to easily and efficiently access the specific building data they need. The DigiBUILD Logbook automatically keeps building information up-to-date and incorporates insights from business intelligence analyses.

Another interesting action towards a common digital building logbook is the study on the development of a European Union framework for buildings' digital logbooks by the European Commission (EU DBL Study) in 2020 [2]. Gómez-Gil et al. in their review mentioned the EU DBL study, which aims to create a standardized approach for collecting, organizing, and storing building-related data across the European Union, establishing a broadly recognized definition of the digital building logbook and laying the groundwork for implementing a digital building logbook model [46].

To summarize, the categories of information of the different logbooks from Horizon2020 projects and the EU DBL study are listed and grouped in Table 4. In particular, a comparison has been made between the categories of indicators, as outlined in the DBL EU study, and the categories of other logbooks.

Table 4. Comparison of different Horizon2020 logbook data structures with EU DBL study.

Categories EU DBL Study	ALDREN BuildLog [36,40,47]	iBRoad Logbook [36,37,46]	BIM4EEB Digital Logbook [27]	X-Tendo Logbook [36]	DigiBUILD Logbook [33]
Administrative information	Building picture	General and administrative information	General and administrative information	Administrative information	General and administrative building information
General information				General information	
Building descriptions and characteristics		Building Construction information	Building Construction information	Building descriptions and characteristics	Building description and characteristics
Building operation and use	Energy verification	Building operation and use	Building operation and use	Building operation and use	Building use and operation
Building performance	Energy rating & target	Building energy performance	Building energy performance	Building performance	Building performance
	Comfort & well-being				
Building material inventory	Documentation—BIM	-	-	Building material inventory	Building material inventory
Smart readiness		Smart information	IoT information	Smart readiness	Smart information
Finance	Cost value risk			Finance	Financial information

Complete alignment with the indicators of the EU DBL study

Partial alignment with the indicators of the EU DBL study

No alignment with the indicators of the EU DBL study

In particular, different colors have been used to highlight the varying degrees of correspondence between them: an exact match is when there is a direct alignment between the categories of indicators, and a partial match is when the category of the considered

logbook does not fully align with the category from the EU DBL study. Additionally, some categories from the EU DBL study do not have corresponding entries in the other logbooks.

By observing Table 4, it is noted that there is a direct correspondence between the X-tendo logbook and the EU DBL study: in fact, the X-tendo logbook follows the structure defined by the European Union [2]. In addition, each analyzed logbook contains a category that aims to describe the identifying characteristics of the building, such as its geometry, location, use, documentation, certifications, technical components, and general ownership information. Departing from the EU DBL study, the two categories "Administrative" and "General" are combined into a single category called "General and administrative information" in BIM4EEB, iBRoad, and DigiBUILD and "Building picture" as defined in ALDREN.

Another category that corresponds in almost all logbooks is "Building descriptions and characteristics", which, in the case of the ALDREN BuildLog, is instead found under "Building picture". This category includes technical information and data about the building's construction, with the architectural and structural features of the building.

Similarly, the "Building operation and use" category is defined in each logbook, and it is called "Energy verification" in ALDREN BuildLog. It contains data on how the building is used, including occupancy rates and operational schedules.

Attention to "Building performance" is given in each logbook, and ALDREN BuildLog has two categories, "Energy rating and target" and "Comfort and Wellbeing", to describe it. It refers to information on energy efficiency, water usage, and other performance metrics.

Moreover, "Smart readiness", as a key category, is included in all the examined logbooks, except for the ALDREN BuildLog. This category focuses on the IoT and smart devices deployed in the building.

"Finance", or "Cost value risk" in ALDREN BuildLog, is another significant category found in all the analyzed logbooks, except for the iBRoad-Log and BIM4EEB. It regards financial data related to building operations, maintenance costs, and potential returns from energy-saving investments.

Finally, "Building material inventory", a key category in tracking and managing the material specifications used in a building, is present in X-tendo logbook and DigiBUILD, and within ALDREN BuildLog under the "Documentation-BIM" category. In ALDREN BuildLog, documentation is categorized as a distinct main category, while in all of the other examined logbooks, various document types fall under the previously established main categories.

3.2.2. Digital Building Logbook Applications in the Building Lifecycle Phase

Considering the building's lifecycle is subdivided into four phases (design, construction, operation/building management, and end of life), each phase offers multiple opportunities for data collection and management [2]. In particular, the digital building logbook potential varies throughout each phase of a building's life cycle. This section offers a detailed analysis and overview of the growing uses of the digital building logbook in the construction industry, with a focus on the specific lifecycle phases. Table 5 shows the number and type of applications that are of interest in the various stages.

Generally, the design phase is crucial for collecting data on the building's physical characteristics, including materials used and their locations. Although the digital building logbook can be useful at every stage of a building's life cycle, one of its most useful applications is in the design phase. The data highlight that 6 of the 25 analyzed papers exploit the digital building logbook in the design phase. During the design phase, the digital building logbook plays a crucial role in enhancing sustainability and circular economy practices in the construction sector. The digital building logbook can be used to store data

on materials and components used in construction, facilitating the identification, recovery, and reuse of materials at the building's end of life [38,43]. This promotes sustainability by contributing to the circular economy through efficient resource management and reduced environmental impact [38,43]. The digital building logbook facilitates the systematic collection of design-related data such as architectural plans and engineering specifications, which are essential for creating a comprehensive design framework. By centralizing this information, the digital building logbook ensures that all stakeholders have access to the latest design updates and modifications [25]. To harness the potential of the digital building logbook, it can be integrated with other technologies such as BIM [44,45,47]. BIM is a collaborative way for sharing and managing multidisciplinary information throughout the building lifecycle, while the digital building logbook gathers and organizes critical building data, such as technical specifications and operational information [53]. Following BIM4EEB implementation, these data can be integrated into or complemented by BIM, which creates a detailed, digital 3D model of the building. BIM enhances the digital building logbook by allowing for the creation, storage, and management of information about the building throughout its entire lifecycle [45].

Table 5. Applications of digital building logbook throughout lifecycle phases in the construction industry.

Phases	Applications	Number of Papers	References
Design phase	Material information repository, Integration with BIM	6	[25,38,43–45,47]
Construction phase	Building data repository, Decision making	3	[25,43,44]
Operation (building management) phase	Monitoring, Energy improvement, Predictive maintenance, Decision making	11	[25–27,29,31,33,38,39,43–45]
End of life	Building diagnosis, Renovation decision making	8	[25,33,37,39,40,43–45]

During the construction phase, a significant amount of additional information is produced. A small number of analyzed papers take into consideration the potential of the digital building logbook during the construction phase. The digital building logbook could be useful in serving as an ideal repository for organizing and storing these data systematically, ensuring that maintenance activities and future interventions are informed and consistent with the building's history. The digital building logbook plays a vital role during this phase by enabling real-time data tracking, documenting changes, facilitating communication, ensuring quality control, and supporting data-driven decision making [44]. These functions contribute to a more organized and efficient construction process, ultimately leading to better project outcomes. The data collected help ensure compliance with regulations and certification schemes [25,43,44].

Data collection in the operation/management phase focuses on the building's operation and performance, covering aspects like maintenance, ownership transfer, and changes in use. The information is valuable for identifying renovation needs and monitoring user behavior. The data highlight that most of the analyzed articles explore the potential of the digital building logbook during the operation phase. Digital building logbooks facilitate long-term data management by ensuring that all relevant information about the building is consistently recorded and maintained [25,27,38,39,43,44]. By recording the operational and maintenance history of buildings, they improve their performance and lifespan, and

they are essential for effective facility management. In fact, this allows facility managers to implement predictive maintenance strategies, optimize energy efficiency, and ensure responsible resource utilization [27,31,43,44]. In addition, performance monitoring is another typical application [31,33]. The use of the digital building logbook for managing building lifecycle data, integrating them with digital twin models, enables the continuous monitoring of building performance over time, offering real-time feedback that can be used for more effective decision making in terms of better building performance and maintenance scheduling [26,27,29,45].

Finally, by providing data on building characteristics, technical conditions, and operational information, the digital building logbook helps improve building management, increase profitability, extend the building's life cycle, allow for building diagnosis, and guide decisions on whether to refurbish, repurpose, or demolish the building and how to optimize material recycling [25,33,39,43,45]. With the increase in renovation activities, the concept of the Building Renovation Passport (BRP), or renovation passports, has been introduced as well. This is specifically designed for existing buildings undergoing phased renovations. While there is no standardized model for the BRP, it is widely agreed that it should include two main components: a digital building logbook that consolidates all building-related information and a renovation roadmap that guides owners through the steps needed to achieve zero-emission buildings by 2050 [44]. Among the articles reviewed, 8 of the 25 analyzed papers deal with the renovation phase. In particular, ALDREN logbook, iBRoad Building Logbook, and Libro del Edificio Electrónico propose a renovation roadmap, supporting the deep renovation of buildings. ALDREN outlines long-term renovation strategies for non-residential buildings based on quality criteria and energy audits, helping property owners avoid the lock-in effect and meet CO_2 reduction targets [40]. The iBRoad Building Logbook is closely connected to the iBRoad Renovation Roadmap, creating a comprehensive toolset for tailoring building renovations, particularly for residential buildings [37]. The LdE-e supports the development of a Scheduled Renovations Roadmap (SRR), which outlines a timeline for necessary renovations. This structured approach helps in organizing renovation activities, ensuring that they are carried out systematically and in alignment with building performance goals [39].

3.2.3. Circular Economy Promotion

Some articles address the digital building logbook concept only marginally, focusing primarily on the material passport (MP). The MP is a comprehensive set of data and indicators that document the characteristics of building materials or systems designed to collect and store comprehensive data on the materials used in buildings with the purpose of enhancing their value for recovery and reuse, thereby supporting sustainable construction practices [32,34,42]. This information is crucial during renovations as it provides insights into the materials' properties, durability, and potential for reuse or recycling, providing critical data for decision making, promoting circular economy practices, and supporting sustainable renovation efforts [24,44]. The integration of MPs with DBLs further enhances their utility in managing building information effectively. The digital building logbook can include a material inventory that functions similarly to an MP, allowing for a comprehensive overview of the building's components and their conditions. This synergy can guide future renovations, upgrades, or deconstruction [34,44].

The implementation of digital technologies, such as BIM and digital twins, can enhance the functionality of material passports [41]. These technologies can help in the collection and analysis of data related to materials, making it easier to manage and optimize their use within the building passport framework [28]. By integrating BIM, the documentation and sharing of building information for future needs are facilitated, addressing the common

issue of there being insufficient information available to construction stakeholders [35]. In addition, this integration allows for a more detailed analysis of the building's components, including their reversibility and sustainability, thus supporting the overall goals of the digital building logbook [42].

Despite their potential benefits, the adoption of material passports faces several challenges such as the financial costs associated with planning for building disassembly and the lack of regulations supporting material recovery. These challenges can hinder the effective integration of material passports into the broader building passport system, limiting their impact on promoting circular economy practices in the building industry [28,34].

3.2.4. Building Data Management

The last topic of investigation concerns data and related management, which includes availability, collection, and organization. One of the primary benefits of the digital building logbook is enhanced data accessibility for stakeholders, including building owners, managers, and regulatory authorities. Effective data management in the digital building logbook allows for the seamless sharing of information among stakeholders. This is essential for collaboration and ensures that all parties have access to the most current and relevant data, which enhances decision-making processes throughout the building lifecycle. By categorizing stakeholders as data providers, data users, or both, the digital building logbook can streamline the flow of information and clarify responsibilities, which is crucial for effective data exchange [25].

As stated in the previous sections, there is no uniform model for the digital building logbook, and hence, the data required differ among countries. Regarding data availability, in a country like Italy that has regional construction legislation, there are a lot of data available at the national level but sometimes some geographic data are available only at the regional level. According to Gómez-Gil et al., municipalities of federalized countries should focus on centralizing data so that they can be supplied through regional digital building logbooks, and then countries can provide a link to national digital building logbooks. Following the examined study, the available data do not completely correspond with the relevant indicators outlined in the existing proposals for a European digital building logbook framework. Additionally, only a limited number of data sources are currently compatible with the digital building logbook, as the majority are not interoperable [36]. Recognizing that data sources for the digital building logbook can be both open and proprietary, Signorini et al. highlight the role of ontologies in extracting, representing, storing, retrieving, and analyzing machine-readable information. They can facilitate data integration and exchange by providing a structured framework and specific vocabulary to describe buildings from various contexts [29].

Concerning the information currently available about buildings, there is a need for additional data collection. To fully leverage the digital building logbook's ability to promote renovations and enhance energy efficiency, it is essential to gather information on actual building performance (including needs and consumption), interior conditions, and user behavior. The rapid growth of networking capabilities has led to challenges in managing the vast amounts of energy consumption data generated by buildings. Most of the data that have been collected are either not publicly accessible or are not stored in databases at all. This situation limits the potential usefulness of the data. Renovation efforts can be hindered by the inefficient querying of these data, which are often stored in data lakes and warehouses. To address this issue, promoting open data is essential, while always ensuring compliance with the General Data Protection Regulation (GDPR) [33,36]. The ALDREN initiative aligns with broader EU strategies aimed at enhancing building data management and improving resource efficiency across the construction sector. It seeks to

overcome barriers like data fragmentation and privacy concerns that have hindered the implementation of such systems in various EU member states [40].

Finally, some papers discuss how blockchain technology can enhance the reliability and trustworthiness of construction logbooks. By utilizing blockchain, the information recorded in logbooks can be securely logged and timestamped, ensuring data security while maintaining public access to non-sensitive information. This addresses issues of data tampering and provides a clear audit trail for all activities on construction sites [27,30,39].

4. Discussion and Conclusions

The paper proposed a systematic literature review aiming to understand the status of the digital building logbook in the AECO field. Sub-questions were defined to address different aspects of the problem and contribute to a more detailed analysis. For this purpose, the study explored current trends related to the use of digital building logbooks, carrying out a bibliometric and thematic analysis. It relied on the use of two scientific databases, Scopus and Web of Science, looking at the period from 2010 to 2024. The quantity of publications acquired remains limited with a total of 25 documents analyzed, indicating a shortage of thorough analyses of this tool. Nonetheless, there has been an increase in the number of publications over the years, with a peak in 2023. Most articles choose a methodological approach that uses case studies for the development of the authors' research, highlighting the main applications of the digital building logbook related to the use phase.

Concerning the thematic analysis of the selected articles, the results on the data that are typically stored in a digital building logbook reveal that no standardized model exists for the building logbook, leading to variations in the data required across different countries. The literature review helped in outlining the categories of information required by logbook proposals and, consequently, in defining which are the main indicators that should be contained within the digital building logbook. The cluster of indicators, as suggested by the collected Horizon2020 logbook proposals, can describe the building and its technical characteristics, as well as the building material inventory. In addition, it can contain financial, legal, and insurance documents, the design and plans for the building, and the design and plans for building interventions. It can record data on the energy efficiency of the building, including energy consumption and certifications, and data from Internet of Things devices installed in the building to monitor systems like HVAC, lighting, and security. The European Commission has made great efforts in the creation and dissemination of this tool. On one hand, the literature review shows that several digital building logbooks have been developed within Horizon2020 European projects; on the other hand, the European Commission's study proposed a digital building logbook framework by identifying the most crucial points through the use of surveys in 2020. However, there is not an official version for implementing this tool within the field yet.

The findings on the digital building logbook supporting the building's entire lifecycle outline its maturity in operations and end-of-life phases, while registering a sporadic use in construction and design phases. This analysis also answers how the digital building logbook impacts facility management. In fact, the digital building logbook facilitates long-term data management by reliably capturing and preserving all pertinent building data. They improve building longevity and performance by recording the history of operations and maintenance, which is essential to efficient facility management. This makes it possible for facility managers to optimize energy usage, implement predictive maintenance plans, and guarantee responsible resource management. By integrating the digital building logbook with digital twin models, building performance may be continuously tracked over time, and real-time feedback can be obtained to enhance decision making about

maintenance schedules and building performance. Furthermore, the digital building logbook plays a critical role in building renovation processes by providing a centralized, digital repository of essential building information. The digital building logbook contains up-to-date information about the condition of building systems (e.g., HVAC, structure, and electrical systems), helping stakeholders assess what needs renovation. By tracking energy consumption and performance, the digital building logbook assists in planning energy-efficient upgrades, which are often a key focus in renovation projects.

The studies also reveal the correlation between the digital building logbook and sustainability. In fact, some articles analyze so-called material passports, which are elements that could be integrated within the digital building logbook, providing information about building materials and enabling better decision making regarding resource allocation, material selection, and renovation strategies.

Data are the keywords when the building logbook is cited. When managing the building, issues occur such as there being a great amount of and variety of data. Therefore, a lot of information needs to be managed. In addition, many building operations data are not updated, incomplete, and in low interoperable formats. Therefore, issues related to data accessibility and gathering can emerge. The data needed to be collected within this tool are various, from energy performance certificates to building envelope and administrative information. Data source accessibility depends on the national context as well. In fact, some data are partially open, while others are non-protected; additionally, others are fully protected and available only to the property owners. Furthermore, poor-quality and varied data are gathered as a result of the absence of universal principles and techniques. For instance, some sources gather data at the building scale, whereas others utilize the residence or building scale.

In conclusion, a digital building logbook, as a common repository for building information, will facilitate data transparency for a variety of stakeholders involved in the construction process since data in a paper-based format, out-of-date as-built data, and the lack of understanding on building components and systems make the selection of the best refurbishment alternatives challenging. This can include a group of informative attributes of and documents for a building that have to be collected during its lifecycle and that can be linked to BIM, tracking changes, and updates. Static data as well as real-time data obtained from Internet of Things devices can be incorporated; data integration will contribute to the regular updates of buildings. It is particularly useful in cases in which project documentation is outdated or unavailable. The digital building logbook is conceived to obtain information not only for facility managers but also for owners, clients, and occupants, allowing for better decision making in maintenance, renovation, and reconstruction projects by offering critical building data, as well as assessments of energy performance and life cycle costs.

Although this research contributes to the knowledge of the digital building logbook by highlighting the relevant publications through a systematic literature review approach, the use of only two databases—Scopus and Web of Science—may have led to the omission of important publications related to the factors influencing the adoption of digital building logbooks in the construction sector. As a result, the research findings may not fully represent the entirety of the existing literature on the drivers of digital building logbook implementation. Additionally, while the key publications were meticulously chosen, the literature search might not have encompassed all relevant keywords.

Future studies will examine the application of this tool on a real case study to test its effectiveness. In addition, how this information can be utilized and shared, focusing on the concept of interoperability, will be analyzed. In fact, even with a tool like the digital building logbook, which gathers building-related data, it is important to explore potential strategies

for exchanging various types of information. Furthermore, it is necessary to investigate the flow of information between different digital building logbook users, understanding who provides what type of data and how the data are exchanged.

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